United States Patent and Trademark Office

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231
www.uspto.gov

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 09/848,479 | 05/03/2001 | Clyde Maxwell Guest | B63814C (013377/0084) | 8534 |

20594 7590 04/29/2002

CHRISTOPHER J. ROURK
AKIN, GUMP, STRAUSS, HAUER & FELD, L.L.P.
P O BOX 688
DALLAS, TX 75313-0688

| EXAMINER | |
|---|---|
| WERNER, BRIAN P | |
| **ART UNIT** | **PAPER NUMBER** |
| 2621 | 6 |

DATE MAILED: 04/29/2002

Please find below and/or attached an Office communication concerning this application or proceeding.

PTO-90C (Rev. 07-01)

| Office Action Summary | Application No. 09/848,479 | Applicant(s) GUEST ET AL. | |
|---|---|---|---|
| | Examiner Brian P. Werner | Art Unit 2621 | |

*-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --*

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE _3_ MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

1)☒ Responsive to communication(s) filed on _03 May 2001_ .

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

4)☒ Claim(s) _27-49_ is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) _27-49_ is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

**Application Papers**

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on _03 May 2001_ is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

**Priority under 35 U.S.C. §§ 119 and 120**

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☒ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

**Attachment(s)**

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _4,5_ .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

## DETAILED ACTION

### *Response to Amendment*

1. The preliminary amendment received on May 03, 2001, has been entered. Claims 27-49 are now pending.

### *Claim Objections*

2. Claim 47 is objected to because of the following informalities: Claim 47 recites, "determining whether a size of an area having a brightness deviation exceeds a predetermined allowable criteria." However, it is unclear from the claim whether the "area" is an area on the histogram, or an actual physical area on the semiconductor die corresponding to a brightness deviation as detected by the histogram. The specification describes both of these interpretations (i.e., figure 6, numerals 610 and 616), and both interpretation are addressed in the art rejections below. Appropriate correction is required (i.e., the claim should make clear whether the "size of an area" is the size of an area on the actual histogram, as seen in figure 6, at numeral 610, or the size of an are on the die that corresponds to the brightness deviation of the histogram, as seen in figure 6, at numeral 616).

### *Claim Rejections - 35 USC § 103*

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. Claims 27-30, 33-37, 40, 41 and 44-46 are rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Sumie et a. (US 5,943,437 A) and Miyazaki (US 6,031,607 A).

Regarding claims 27, 33-35 and 44-46, Sumie discloses a die inspection system wherein a reference die is selected ("the reference image" at column 7, line 50) comprising:

a die image comparator (figure 6, numeral 3a) creating a difference image ("difference is calculated pixel by pixel" at column 5, line 31; figure 7, numeral S2) from a first die image ("reference image" at column 5, line 29) and a second die image ("inspection image" at column 5, line 28); and

a difference image analysis system coupled to the image comparator (figure 6, numeral 4; figure 7, numeral S4-S5) used to determine whether the first die image and the second die image may be used as the reference die (Sumie relies upon a "reference image" of a semiconductor die for comparison with an inspection image for purposes of determining a defect in the inspection image. The reference image is stored in memory 3c of figure 6. Sumie discloses how the reference image is selected at column 7, lines 50-56, wherein he states, "the reference image data $ID_c$ to be stored in the image

memory 3c of the image processor 3..may be data of an image obtained by picking up an image of a portion of the surface of the semiconductor wafer where there is no defect". Phrased differently, Sumie states that "when an image of the semiconductor wafer 1 in a position where no defect exists is further picked up to use as a reference image, the 'position including no defect' which is output from the defect inspection apparatus may be used for the image pickup operation as the position of the reference image" at column 9, line 1. Thus, Sumie perform an inspection operation on the wafer in order to determine a position on the wafer where a defect free reference image can be found, and then uses the defect free image as the reference image. Sumie discusses how this is done, specifically in relation to the inspection of semiconductor dies, at column 8, lines 46-60. Sumie states, "in the case of a semiconductor wafer on which the same construction (die) repeatedly appears, a defect portion can be extracted by comparing the pieces of luminance..of the dies with each other" at column 8, line 50. Regarding the comparison of at least two dies for purposes of determining if a defect exists, Sumie states, "when the same part of three dies is extracted by the inventive method, if the pieces of luminance information..substantially agree within a specified tolerance, no defect is determined to exist in the test regions of the three dies" and if the luminance "extracted from one die differ from those extracted from the remaining two dies, a defect exists in the test region of this one die" at column 8, line 58. Thus, Sumie compares at least two die images, as called for by the claims [i.e., the claims are open ended], in order to determine whether a defect exists, and then uses a defect free dies as the reference image).

Regarding claim 33 specifically, Sumie discloses a camera (figure 6, numeral 2b).

Regarding claim 28, Sumie disclose an imaging system creating a digital image (figure 6, numeral 2).

Regarding claim 29, Sumie disclose an image store (figure 6, numerals 3b-3g).

Regarding each of the claims, Sumie does not disclose the difference image analysis generating histogram data from the difference image and analyzing the slope of the histogram data to identify a region over which the slope of the histogram changes in order to determine whether the first and the second die image may be used as the reference die image. Specifically regarding the apparatus limitations of claims 30, 36 and 37, Sumie does not disclose a data sorter for generating the histogram, and a slope analyzer for analyzing the histogram commensurate with the aforementioned image analysis.

Miyazaki discloses a semiconductor wafer inspection system ("defect inspection system" at column 1, line 7) comprising defect detection circuitry that analyzes a difference image ("difference image is formed" at column 14, line 64) by generating histogram data from the difference image ("difference image providing the brightness histogram" at column 15, line 6; figures 17 and 18) and analyzing the slope of the histogram data to identify a region over which the slope of the histogram changes (first, the initial slope on the dark end of the histogram is analyzed; i.e., "the amount of the slope of this line is calculated to obtain the absolute value" at column 15, line 4; then, a threshold is set in dependence on this slope as described at column 15, line 42-50, and

a "portion brighter than a given uniform brightness (threshold value) is recognized as a defect" at column 15, line 34; in the context of this quote, and looking at figure 17 for example, the brightness peaks that appear in the histogram at areas that are greater than threshold "P1" are regarded as defects, or potential defects; if there were no peaks greater than P1, and thus no slope changes after the initial slope, then the difference image would be considered defect free; the peaks appearing in figure 17 that are greater than P1 are changes in the histogram slope, and represent potential defects, thus meeting the claim requirements).

Regarding claims 30, 37 and 41 specifically, the system disclosed by Miyazaki that performs the slope detection steps as described above is a slope detector.

Regarding claims 36 and 40 specifically, the system disclosed by Miyazaki that generates the histograms is a data sorter, as brightness data must be sorted into bins related to how much data is present at each brightness level (i.e., "brightness histogram" at column 15, line 6); as this is how a histogram is generated.

It would have bee obvious at the time the invention was made to one of ordinary skill in the art to analyze the difference image Sumie, using the histogram techniques as taught by Miyazaki, in order to determine whether a defect exists in dies, and thereby gaining the benefit of the Miyazaki analysis which "permits the individual setting of threshold value for portion of much noise and portion of less noise, producing the pattern defect inspection with high accuracy and enlarging the object of inspection" (Miyazaki, column 15, line 55).

5. Claims 27, 33 and 44 are rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Sumie et al. (US 5,943,437 A) and Brecher et al. (US 5,544,256 A).

Sumie discloses a system for selecting a reference die as described hereinabove.

Regarding each of the claims, Sumie does not disclose the difference image analysis generating histogram data from the difference image and analyzing the slope of the histogram data to identify a region over which the slope of the histogram changes in order to determine whether the first and the second die image may be used as the reference die image.

Brecher discloses a system in the same field of endeavor of optical inspection (see figure 1), and same problem solving area of analyzing a difference image for defects (see "difference image...corresponding to a defect" at column 13, line 30), comprising the generation of a histogram from the difference image (figure 15; see "distribution of pixels in the difference image" at column 13, line 28) and analyzing the slope of the histogram data (see "interior contrast ratio" at column 13, line 33) to determine a defect (if the interior contrast ratio is high, the "defect is bright" at column 13, line 41). The purpose of this histogram analysis, as stated by Brecher, is to determine from a difference image, whether defect pixels (if they exist) are brighter or darker than the template as described at column 13, lines 25-30. Brecher states that "[f]requently, there is a need to decide whether a defect is dark or bright" (column 13, line 5) in order to decide how serious the defect is through classification (see column 5, lines 5-20).

Specifically regarding the slope analysis limitation, Brecher's interior contrast ratio is equal to $(N_{brighter})/(N_{brighter} + N_{darker})$ as seen at column 13, line 33. The term $N_{brighter}$ refers to the number of pixels in the histogram that are brighter than the template, and the term $N_{darker}$ refers to the number of histogram pixels that are darker than the template. It can be seen from the histogram of figure 15 that there are two modes, and thus two distinct areas under the curve. The left area indicates the number of darker pixels and the right area indicates the number of brighter pixels. Each area is a distribution, having a positive and negative slope. Thus, given the interior contrast ratio equation, one analyzes the existence of the slopes in the difference image histogram as follows. In a case where there are only bright pixel differences, the ratio would be $(N_{brighter})/(N_{brighter} + 0)$ which is equal to one. This happens because there is no dark pixel distribution and thus no dark pixel slopes. In a case where there are only dark pixel differences, the ratio would be $(0)/(0 + N_{darker})$ which is equal to zero. This happens because there is no bright pixel distribution and thus no bright pixel slopes. In the case where there are equivalent numbers of bright and dark pixels, meaning that both distributions appear, each having slopes as seen in figure 15, then the ratio is N/(N+N) which is equal to .5. Thus, as the bright and dark distributions change, the ratio changes from zero to one. When the ratio is one, only bright pixels are present. When the ratio is zero, only dark pixels are present. When the ratio is between zero and one, there is a change from a negative slope of the dark pixel distribution to a positive slope of the bright distribution meaning that there are both bright and dark pixel defects. Thus, Brecher's interior contrast ratio is an analysis of slops present in the histogram,

thus meeting the claim requirements. The claims make no specific requirements regarding the type of analysis, the details of the analysis, or any procedures involved in analyzing the slope, other than that the slopes are "analyzed". None of the claim limitations preclude the Brecher teaching from meeting the claim limitations. In addition, Brecher also determines a negative to positive slope change from the values $\Delta_{positive}$ and $\Delta_{negative}$, which are the average values of the positive and negative difference distributions as seen at figure 15 and described at column 13, lines 35-45. The "average" values exist right at the center of the distributions where the slopes changes from negative to positive. Brecher uses these values to determine an "interior contrast magnitude" at column 13, line 38, which is a "measurement for a defect in a patterned semiconductor wafer" at column 14, line 11, as listed in Table 5, at column 15. Brecher uses this technique to decide whether a "defect is dark or light" (column 13, line 5) in order to classify the defect (column 4, lines 35-50), as defect classification has become an "essential part" of the manufacturing process "where defect detection is critical", as "classification provides the information necessary to correction process or production problems" (column 1, lines 15-25; also refer to columns 14-15).

It would have been obvious at the time the invention was made to one of ordinary skill in the art to combine the teaching of Brecher with Sumie, by generating a histogram from Sumie's difference image and analyzing the histograms for the presence of bright and dark pixel difference slopes as taught by Brecher and described above, to determine the presence of bright and/or dark pixel differences which is "indicative of foreign material on top of the surface" (Brecher, column 12, line 61), and thereby better

classify the types of defects present and thus determine seriousness and nature of the defect.

6. Claims 31, 38, 42 and 47 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sumie et al. (US 5,943,437 A) and Miyazaki (US 6,031,607 A) as applied to claims 27, 36, 40 and 44, and further in view of Michael (US 5,640,200 A).

The Sumie and Miyazaki combination does not teach a size detector for determining whether a size of a region in the difference image exceeds an allowable size. Regarding claim 47 specifically (**see the claim objection above**), Sumie and Miyazaki combination does not teach determining whether a size of an area on the die corresponding to a brightness deviation detected in the histogram exceeds an allowable size.

Michael discloses a system in the same field of optical inspection (figure 7) and same problem solving area of determining defects in a difference image (see "difference image" at column 10, line 21) comprising the determination of a defect size within the difference image ("defect size" at column 15, line 60; "measuring..area" at column 16, line 30; see equations 10a and 10b at line 45). Michael states that use of geometric criteria, such as size and area, impose "additional criteria to prevent false alarms" (column 15, line 58).

It would have been obvious at the time the invention was made to one of ordinary skill in the art to impose size as a defect criteria as taught by Michael, for the determination of potential defects on a die as identified by the histogram analysis of the Sumie and Miyazaki combination, in order to impose additional criteria for determining a

defect to prevent false alarms, and the false determination of a defect in an otherwise good wafer die.

7. Claims 32, 39, 43, 48 and 49 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sumie et al. (US 5,943,437 A) and Miyazaki (US 6,031,607 A) as applied to claims 27, 36, 40 and 44, and further in view of Berezin et al. (US 5,539,752 A).

The Sumie and Miyazaki combination does not teach the calculation of defect density for comparison with a predetermined criteria for density. Regarding claims 48 and 49 specifically (**see the claim objection above**), Sumie and Miyazaki combination does not teach determining whether a number of areas on the die corresponding to a brightness deviation detected in the histogram exceeds an allowable number of deviations per unit area. Regarding claim 49 specifically, Sumie discloses other image data (color data at column 8, line 35).

Berezin discloses semiconductor wafer inspection (figure 1) wherein Berezin teaches providing a warning when "defect density, or number of defects per die, exceeds preselected parameters" at column 3, line 52, such as "when the number of defects of a certain defect type for a given die exceed a threshold value, or when the defect density for a certain defect type exceeds a threshold value, thereby indicating yield-detracting operations of the manufacturing process" at column 5, lines 5-13.

It would have been obvious a the time the invention was made to one of ordinary skill in the art to compare the density of defects on a die as determined by the histogram

analysis of the Sumie and Miyazaki combination, with a predefined criteria as taught by Berezin, in order to flag potential defects between dies, and to flag yield-detracting operations of the manufacturing process so that the operator can take corrective action.

8. Claim 31, 32, 38, 39, 42, 43, 47, 48 and 49 are rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Sumie et a. (US 5,943,437 A) and Miyazaki (US 6,031,607 A) as applied to claim 44, and further in view of Litt et al. (US 5,091,963 A).

Regarding claim 47, the Sumie and Miyazaki combination teaches the identification of the region over which the histogram slope changes (e.g., Miyazaki, figure 17, the slope of the histogram changes as seen by the various small peaks in the area brighter than threshold P1) where brightness deviations are detected (e.g., the peaks in the histogram of figure 17 to the right of P1).

The Sumie and Miyazaki combination does not teach the identification of the region over which the histogram slope changes as comprising as determining whether a size of an area **on the histogram (see the claim objection above)** having a brightness deviation exceeds a predetermined allowable size.

Litt discloses a semiconductor inspection system (figure 1) comprising forming a histogram (figure 10) of a difference image ('subtracting' at column 2, line 36), and determining whether a size of an area having a brightness deviation ('standard deviation and MPD' at column 12, line 21; the standard deviation of a histogram represent a size of that histogram, in terms of the average deviation from the mean value) exceeds a

predetermined allowable size ("threshold values established by testing wafers having no discernable isolated contrast areas" at column 12, line 19).

It would have been obvious at the time the invention was made to one of ordinary skill in the art to analyze the histogram peaks outside of the threshold of the Sumie and Miyazaki combination, by comparing their size (i.e., a standard deviation) to a threshold as taught by Litt, in order to provide a "statistical measure" for determining whether a defect is present, which "inherently correct for non-uniformities in illumination" (Litt, column 11, line 3).

Regarding claims 31, 38 and 42, the Sumie and Miyazaki combination does not teach a size detector, determining whether an anomalous region corresponding to brightness variations in the histogram exceeds a predetermined allowable size.

Regarding claims 32, 39, 43, 48 and 49, the Sumie and Miyazaki combination does not teach a density detector, determining whether a number of anomalous regions corresponding to brightness variations in the histogram exceeds a predetermined allowable number of anomalous regions per unit area.

Litt discloses an inspection system as discussed above, comprising a size and density detector, determining whether a number of anomalous regions corresponding to brightness variations in the histogram exceeds a predetermined allowable number of anomalous regions per unit area and whether a predetermined allowable size is exceeded ("number of isolated contrast variations on a wafer or other article surface and the area and equivalent diameter of each of those variations" at column 13, line 29; see Tables 1 and 2).

It would have been obvious at the time the invention was made of one of ordinary skill in the art to analyze the size and density of defects, as determined by the histogram analysis of the Sumie and Miyazaki combination, to determine whether a predetermined size and density criteria is met as taught by Litt, in order to establish "criteria concerning the number of contrast variations [i.e., defects] and their respective areas [i.e., sizes] that may acceptably appear on an exposed surface" (Litt, column 2, line 6), and provide "different acceptability criteria...to articles of different sizes" (Litt, column 13, line 45) to thereby establishing a variable criteria for the determination of acceptability for "a particular use" (Litt, column 2, line 27).

### *Conclusion*

9. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Brian P. Werner whose telephone number is 703-306-3037. The examiner can normally be reached on M-F, 8:00 - 4:30.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Leo H. Boudreau can be reached on 703-305-4706. The fax phone numbers for the organization where this application or proceeding is assigned are 703-872-9314 for regular communications and 703-872-9314 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-305-4750.

Brian Werner
Patent Examiner
April 23, 2002

**BRIAN WERNER**
**PATENT EXAMINER**
**ART UNIT 2621**